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GEOLOGY.—*Middle Devonian pelecypods of Wisconsin and their bearing on correlation.*[1] ERWIN R. POHL, Vanderbilt University.
(Communicated by R. S. BASSLER.)

INTRODUCTION

It has been the pleasure and privilege of the writer for the past three years to engage in a coöperative effort, under the auspices of the United States National Museum and the Milwaukee Public Museum, to understand more fully the fauna of the Wisconsin Devonian formations and the relationship of these formations to those of other areas. A small, roughly semicircular patch in south-eastern Wisconsin preserves Middle Devonian rocks and a lone outlier near the Keweenaw on Lake Superior, Limestone Mountain, has yielded fossils of Helderbergian type. The latter are few, however, and their isolated presence in the north can shed no direct light on the connections of the Middle Devonian beds. The only significant fact to be learned from them is that of marine deposition on the flanks of the old Laurentian positive area.

The discovery of Middle Devonian types of fossils long ago established in a general sense the age of the Milwaukee and Ozaukee County deposits, but the literature shows a progressive tendency on the part of paleontologists to recognize the impropriety of unreserved identifications of the Milwaukee species with those described from New York, Ohio, Michigan, and Iowa. This tendency has brought into question the hypothetical narrow strait assumed to occupy in Mid-Devonian time a position within the present boundaries of Wisconsin and Michigan and to allow either complete or limited communication

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between enormous contemporaneous eastern and western arms of the sea. It has recently been shown that the formations to the west in Iowa, to whose described forms many Wisconsin species were compared, belong not to the Middle but to the Upper Devonian—a fact in itself sufficient to put to rest the assumption of contemporaneity of the New York, Wisconsin, and Iowa species. Finally, from evidence afforded by a close study of the pelecypod fauna of the Milwaukee beds comes the conviction that there has been no commingling of faunas or species from the east and west.

As early as 1882 Whitfield, in describing several new species from the Milwaukee formation, pointed to differences in many others. In 1899 Teller and Monroe, amateur collectors but nevertheless close students, recognized enough difference in many fossils to compare them with nearly related described forms rather than to identify them unreservedly. H. F. Cleland described 35 new and well founded species and pointed to striking dissimilarities from described forms in as many more species although allowing them to remain within the scope of those forms. John M. Clarke, than whom in the past generation none had better knowledge of the New York Devonian, in personal correspondence with Cleland frequently placed his sanction on an identification of a Wisconsin species with one from New York only with the reservation that a question mark be annexed. The Echinodermata, as studied by Weller, Springer, and Cleland, show the distinction particularly well, for they belong almost without exception to completely differentiated and easily distinguished new types. The pelecypod association is unique, not a single instance having been found of unquestionable identification with forms elsewhere described.

Wisconsin Devonian Pelecypods

The Devonian section of eastern Wisconsin comprises three phases, separated from each other at present primarily on the evidence of the contained faunas rather than upon stratigraphy. Table 1 gives complete lists of the various pelecypod associations, and it need be remarked here only that specific distinctions are sharp between the lamellibranchs of the three formations.

In the Ozaukee and Thiensville beds (manuscript names used by G. O. Raasch for the lowermost phase of the Wisconsin Devonian), the preservation of the pelecypods is inadequate for more than generic comparison. The genera, among them *Conocardium, Schizodus, Janeia, Sphenotus, Leiopteria* and *Leptodesma,* are well-advanced

Devonian types and it is a little surprising to discover them at the base of the Devonian column in Wisconsin. The association would suggest a derivation similar to that of part of the lower Cedar Valley of Iowa.

The Lake Church formation (manuscript name of G. O. Raasch), the stratigraphic position of which is still in question, has yielded a small, but unique assemblage of fossil pelecypods. The derivation of the materials and of the fauna is not known. It is difficult to believe that an association of species so remarkably differentiated should have developed indigenously in as short a time and under as normal a condition as is indicated by the less than 20 feet of pure, dolomitic limestone to which, so far as known, they are confined. The presence of generic types known to have a northern origin such as *Ilionia*, *Conocardium* (*altum* and *brevialatum* groups), *Paracyclas* (*"elliptica"* group), *Schizodus* (*appressus* group), and *Lophonychia*, leads to the supposition of north-eastern if not Arctic connections for this fauna.

The Milwaukee formation contains a very abundant pelecypod fauna—43 species in 19 genera. The relationships of this fauna are with the North-Atlantic Hamilton fauna, whose typical development is in eastern New York (Table 2).

Middle Devonian of the Central Basin

Throughout extended stratigraphic work in the Middle Devonian of the Central Basin an understanding of the interrelations of the formations and their contained faunas has been the chief objective. The predominantly Hamilton aspect of the Milwaukee fauna has already been noted, and in searching for the path of its incursion we are immediately struck by its faunal isolation. In the remarkably complete development of Erian deposits in the adjacent south and east we look in vain for faunal connections. The contemporary invasions into the states on the south—Missouri, Illinois, Kentucky, Indiana, and southern Ohio—brought in generic types known to have a southern derivation and totally unlike the Milwaukee forms.

Of other comparable sections we have only the profusely fossiliferous Michigan series. It is natural to look toward these nearest Middle Devonian deposits for illumination, but here a hitherto entirely unsuspected problem arises. Only the salient features of the Michigan section and the exact stratigraphic position it holds will be noted here, for the detailed sections and evidence for the assignments made are the subjects of present studies by the author. The Silica shale of northwest-

TABLE 1.—Stratigraphic Distribution of Species

A. Milwaukee Formation

	Zones.		
	A.	B.	C.
Grammysia ulrichi Pohl	....	×	....
G. marginata Pohl	....	×	....
G. regularis Pohl	....	×	....
Cimitaria obtusiloba (Cleland)	....	×	....
Edmondia fragilis Cleland	....	×	....
Nucula triangula Pohl	....	×	....
Nuculites laphami Cleland	....	....	×
Palaeoneilo milwaukeensis (Cleland)	....	....	×
P. sp. cf. *constricta* (Conrad)	....	×	....
P. pulchella Pohl	....	?	×
P. devexa Pohl	....	×	....
P. corrugata Pohl	?	×	....
P. corrugata angulata Pohl	×	....	....
P. persinuata Pohl	....	....	×
P. dentata Pohl	....	....	×
Nuculana gibbosa Pohl	....	....	×
Megambonia wisconsinensis Cleland	×	....	....
Leiopteria acutilaris Pohl	....	....	×
Actinopteria rhombolineare Pohl	....	....	×
A. pauciradiata Pohl	×	....	....
A. singularis Pohl	....	....	×
A. sp.	....	×	....
Mytilarca cingulosa Pohl	....	×	....
M. dentata Pohl	....	×	....
Plethomytilus subercctus Pohl	....	×	....
Lophonychia cultellata Pohl	....	×	....
Conocardium ornatum Cleland	....	....	×
Aviculopecten basslcri Pohl	....	....	×
A. hystriculus Pohl	....	....	×
A. duplicostatus Pohl	×	....	....
A. sp.	....	....	×
Vertumnia telleri Cleland	....	×	....
V. simplex Pohl	....	....	×
V. barretti Pohl	....	....	×
V. intercalaris Pohl	....	....	×
V. edwardsi Pohl	....	....	×
V. raaschi Pohl	....	×	....
Schizodus dubius Pohl	....	×	....
Modiomorpha saccula Pohl	....	×	....
M. clongata (Cleland)	....	×	....
M. pediformis Pohl	....	×	....
M. obliqua Cleland	×	....	....
M. mytiloides milwaukeensis Pohl	....	×	....
M. schucherti Cleland	....	×	....
Paracyclas paradoxica Pohl	....	....	×
P. sp.	....	×	×

B. Lake Church Formation

?Pterinea paucicostata Cleland
Actinopteria convexa Pohl
Lophonychia trigonale (Cleland)
Conocardium truncatum Pohl
C. auritum Pohl
C. intersculptum Pohl
Schizodus acutangulus Pohl
Paracyclas obesa-umbonata Pohl
P. elliptica milwaukeensis Pohl (?)
Ilionia tenuistriata (Cleland)

C. Ozaukee and Thiensville Beds

Conocardium sp.
Schizodus sp.
Janeia cf. *vetusta* Meek
Sphenotus cf. *contractus* (Hall)
S. sp.
Leiopteria sp.
Leptodesma sp.

TABLE 2.—Taxonomic Affiliation of the Pelecypods of the Milwaukee Formation

Wisconsin	New York (Lower Hamilton)
Grammysia ulrichi Pohl	*G. nodocostata* Hall
G. marginata Pohl	*G. nodocostata* Hall
G. regularis Pohl	*G. arcuata* (Conrad) *G. subarcuata* Hall
Cimitaria obtusiloba (Cleland)	*C. recurva* (Conrad) *C. corrugata* (Conrad)
Palaeoneilo sp. cf. *constricta* (Conrad)	*P. constricta* (Conrad)
P. dentata Pohl	*P. constricta* (Conrad)
P. corrugata Pohl	*P. emarginata* (Conrad)
P. corrugata angulata Pohl	*P. emarginata* (Conrad)
P. pulchella Pohl	*P. fecunda* Hall
P. devexa Pohl	*P. maxima* (Conrad)
Nuculana gibbosa Pohl	*N. rostellata* (Conrad)
Megambonia wisconsinensis (Cleland)	*M. cardiiformis* Hall
Leiopteria acutilaris Pohl	*L. conradi* Hall
Plethomytilus suberectus Pohl	*P. oviformis* (Conrad)
Conocardium ornatum Cleland	*C. cuneus* (Conrad)
Actinopteria rhombolinearis Pohl	*A. boydi* (Conrad) *A. quadrula* (Conrad)
Vertumnia barretti Pohl	*V. reversa* Hall
V. simplex Pohl	*V. avis* Hall
Modiomorpha saccula Pohl	*M. concentrica* (Conrad)
M. elongata (Cleland)	*M. concentrica* (Conrad)
M. pediformis Pohl	*M. mytiloides* Hall
M. mytiloides milwaukeensis Pohl	*M. mytiloides* Hall

ern Ohio is nothing more than the exact equivalent of the Bell shale at the base of the Michigan Traverse. At Silica the Bell shale rests disconformably on the Columbus limestone (of true Onondaga affinities). Thus the lower boundary of the Traverse is definitely established. Three oscillatory phases of the Traverse are developed on the two sides of the state, in the northern part of the southern peninsula, to a maximum thickness exceeding 500 feet. The Thunder Bay phase, or uppermost division in eastern Michigan, carries a peculiar and profuse assemblage of species which are also to be found in the lowest exposed beds across Lake Huron in Ontario. The top of the beds in Ontario, the so-called Olentangy shale, is separated by overlap from the succeeding "Widder beds," which in turn are directly correlatable with the middle of the Hamilton section at East Bethany, in central New York. Upper and lower limits are thus clearly defined for the Michigan Traverse, no part of which is correlatable with the true Hamilton of eastern New York. The Marcellus deposits may be in part a time-equivalent of the Traverse, but stratigraphic evidence indicates a minimum of 500 feet of interruped limestone deposition in the east-central Basin between the Onondaga and the Hamilton. In view of the stratigraphic position occupied by the Traverse, despite the fact that it also is of northern invasion, it is not unexpected that we find no relation of faunas nearer than generic similarity between the Milwaukee and the Michigan beds.

The upper Devonian age of the Iowa formations has already been noted, and by the process of elimination we are left with only inferential faunal and stratigraphic evidence of the derivation of the Wisconsin Devonian.

Conclusion

The northern complexion of the Milwaukee fauna, the complete lack of stratigraphic equivalents in surrounding regions, the isolation of the area, the singularity of specific types, and their close although easily distinguishable relation to the north-Atlantic Hamilton, has thus far been summarily reviewed. Alternative paths of seaway encroachment now suggest themselves. Considering the possibility of approach by way of the South Laurentian-St. Lawrence trough, no indications of ingress by that route are afforded. Contrarily, the possibility is denied by the present absence of Devonian beds and the resulting necessity for complete removal of all Devonian beds from this area subsequent to deposition. Thus we arrive at the assumption

that the invasion encroached from the north by means of connection with James Bay around the north of the Laurentian positive area.

The unique assemblage in the limited area in eastern Wisconsin can not be considered an indigenous fauna because of its close connection with that confined to the Hamilton (Skaneateles) of eastern New York. The specific distinction is rather to be explained on the basis of non-contemporaneity, since both faunas were derived from the same mother oceanic association. Absence of several types or the presence of new ones in either of the areas is incidental and due to the changing character of the associations in the permanent basins and the ecologically varying conditions in the two regions. Stratigraphic and faunal inferences necessitate an extremely late Erian time equivalency for the Milwaukee formation, and it is probable that all of the Devonian in the eastern part of Wisconsin is later in deposition than any portion of the typical Hamilton.

PALEONTOLOGY.—*The status of the classification of the trilobites.*[1] E. O. ULRICH, U. S. Geological Survey.

The classification of the trilobites in both modern and older textbooks suggests that they fall as readily into line as though made to order. The genera and families seem sharply defined, and the descriptions seldom indicate any doubt regarding the soundness of the arrangement. However, the critical student who seeks to prove the indicated relationships for himself soon notes discrepancies and incongruities that grow and multiply till his confidence is weakened and finally almost destroyed. Such at least has been my experience during the twenty years or so that I have devoted mainly to the study of one after another of the genera and families of trilobites. The results of these studies, usually at variance with the views of the authorities, are only now being completed to the point where I might consider myself warranted in publishing them. But they were extensively employed and have always been available as paleontological criteria in the stratigraphic investigations that primarily occasioned the study of the fossils.

Prevailing conceptions regarding the systematic relations of the Ordovician and older trilobites are too largely based on overworked theories, weakly grounded deductions, and pure assumptions employed indiscriminately as though they were established facts and immutable

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